TITLE: A High Speed Finger-Print Optical Scanning Method

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ABSTRACT

An optical scanning technique of dactylogram (fingerprint) has been developed by using plural LED's with different wavelength as emitting elements and a color CCD or CMOS area image sensor as receiving element. Owing to the R/G/B filters built in that color area image sensor, if the above LED's have wave lengths corresponding to those peak sensing wavelengths of the R/G/B outputs of that color area image sensor, and if the above mentioned LED's are installed to emit light on the surface of finger from different directions, then it will be effective to get a 3D picture by using a single color area image sensor. Moreover, the time needed to obtain a 3D picture is only that for single exposure.

Thanks to the inherent nature of 3D picture, the sharpness of border of the ridges of a fingerprint in the picture is greatly enhanced. This simplifies the data transmission. Besides, by a simple signal processing of those output waveforms of the color area image sensor, the security against counterfeiting in fingerprint identification can be easily ensured. These features are essential for fingerprint authentication in INTERNET environment and E-Commerce environments.

Keywords: fingerprint, optical scanning, plural LED, identification, E-commerce

1. INTRODUCTION

Recently the biometrics revolution is coming to life. For the past years, those biometric technologies which are used to identify people through fingerprints, facial, voice pattern and other physical characteristics has existed for years, in view of those requirements in INTERNET environment where many users are on line simultaneously, the demand of technological breakthroughs always exists for quicker response, greater convenience and higher security.

Among those biometrics technologies for authentication, from the view point of convenience and higher security, dactyloscopy is by far the best, much better than the current system like keycard, passwords and personal identification numbers (PIN).

And among those various methods for reading fingerprints, by using sensing technologies using static capacitance, thermal or optical detection, the optical detection is by far with the most potential to meet the requirements in INTERNET environment owing to the recently fast progress in E/O device such as LED and color CCD/CMOS image sensor.

In the following we will propose a newly developed optical scanning method[1] to take the full benefit of the recently plurality of high luminesce LED's with different wavelengths corresponding to those peak sensing wavelengths of the R/G/B outputs of the detecting device (the color area image sensor), a 3D-like image pattern can be obtained by using a single receiving element within a single exposure time period. These two or three output signals are stored in analog form in the color area image sensor; these output signals can be simultaneously processed to give a very clear fingerprint pattern by using very simple circuitry. Besides, these analog signals can also be used for the detection of counterfeiting of fingerprint.

With the method no additional semiconductor memory is required during signal processing of these outputs, and prevention of counterfeiting can be manipulated by using only simple explains the high speed sensing nature of fingerprint pattern of this design.

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2. SOME WAYS FOR FINGERPRINT SENSING

As the background for the evaluation of that high speed sensing method of fingerprint pattern, the currently used methods to get fingerprint pattern for subsequent matching and identification use will be briefly described below; these methods can be classified into four categories[2-4]:

2.1 Ink-based fingerprint (paper based fingerprint)

This is the conventional way commonly used by governments and public agencies for years. This conventional fingerprint matching method is quite time-consuming. And this kind of paper based fingerprint data is not easy to use.

2.2 Heat based sensing

This is not so widely accepted at the present time due to the low resolution of the inherent nature of thermal imaging technique. Besides, this method is easily influenced by environmental changes such as temperature changes.

2.3 Static capacitance sensing

In this method the static capacitance between the electrode plate and the surface of finger is detected. Since the surface of finger is structured with ridges and valleys over the whole region, thus the difference in height of the top of ridges and the bottom of valleys are used for the distinguish of fingerprint pattern.

The advantage of static capacitance detection is easy to use and simple in hardware structure. However, it suffers the disadvantage that the static capacitance is very sensitive to moisture. Therefore, this method will encounter some difficulties in case of sweated hands or in high moisture conditions. Another disadvantage of the dactyloscopy by capacitance detection is its limited resolution and poor edge sharpness of the pattern due to the fact that the electric field in the vicinity of the micro pads of a capacitor may diverge.

2.4 Optical scanning method

This method senses difference of the intensity of reflected light from the ridges and valleys. The reflected light from the ridges of surface of finger is higher than that from the valleys.

Three basic units are required to construct an optical scanning module, namely (1) light source, (2) lens system and (3) B/W area image sensor. Fig.1 illustrates this method.

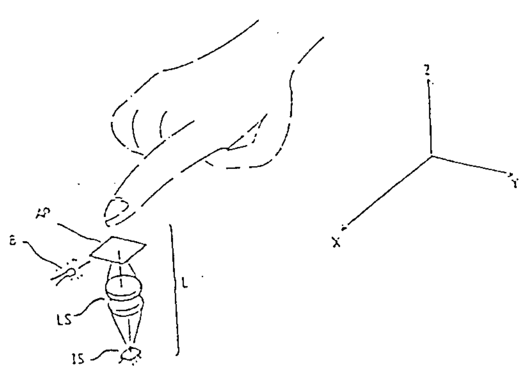

Figure 1. Schematic of an optical scanning method

For the purpose of area image sensor to receive the reflected light from surface of a finger, light should be emitted from below (vertically or obliquely) upon the surface of the finger, as be seen in Fig.1. Two signal processing methods are commonly used as explained as below:

2.4.1 2D image scanning

Since the whole area of the surface of the finger is illuminated by lights from all directions, each side (for example the left side) of bottom of a "valley" which is scarcely illuminated by the light from the corresponding (i.e. left) side will be exposed to the light from another (i.e. right) side. Thus the darkness of the margin decreases. This means the contrast between the darkness/brightness is weakened. Thus the sharpness of the border lines of the ridges and valleys is poor, as depicted in Fig. 2.

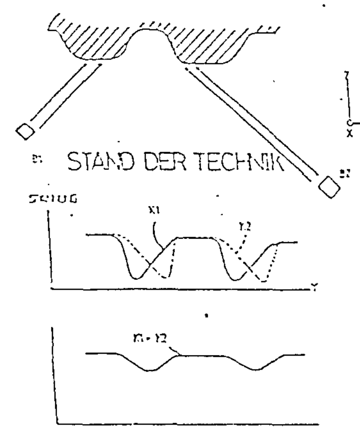

Figure 2. Standard technique of 2D image scanning where the sharpness of the border lines of ridges and ridges is poor

2.4.2 3D image scanning

If the light sources at the left side and at the right side are turned on separately in sequence and the image pictures are taken two times respectively by the two sequences, then it is a way for obtaining the 3D image pattern, For example, one image pattern will show the pattern as lighted from left direction, and the other image pattern shows those as lighted from right direction. The darker area of these two image patterns are not alike, thus defining a 3D picture.

However for the processing of these two image patterns, a memory with enough capacity is needed; one of the image patterns that is taken at first should be stored in the memory. Then this information will be retrieved out and be processed together with information of that second image pattern. This is illustrated in Fig.3.

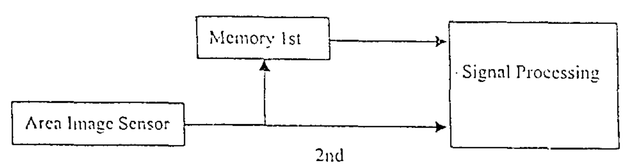

Figure 3. The processing of 3D image scanning, where an additional memory is needed for the storage of the first image pattern

3. IMPROVED 3D OPTICAL SENSING METHOD

Fig.4 shows an improved method for fingerprint pattern scanning, wherein a color area image sensor and LED's of different primary colors are used. This color area image sensor will has three outputs (here we call R/G/B outputs, with built-in R/G/B optical filters in their receiving pixels.) The LED's used to respectively light the surface of finger from different directions have different colors (and therefore wavelengths) corresponding to the peak sensing wavelength of the R/G/B

output of the above mentioned color area image sensor. This is shown in Fig. 4.

By employing this hardware structure, if all these LED's light simultaneously, this means the color area sensor will receive the reflected light from all these LED's. For example, if only two kinds of LED's namely RED and GREEN are used, they emit RED and GREEN light respectively with peak wavelengths matching the peak sensing wavelength of the R output and G output of that color area image sensor, respectively.

Then the R output and G output will show the separate image patterns which are produced only by RED LED's or GREEN LED's, respectively. Since the RED LED's and GREEN LED's are installed to emit light out from different directions, the 3D image pattern can be obtained with a single exposure. Moreover, no memory is needed in this hardware structure. This is shown in Fig.5.

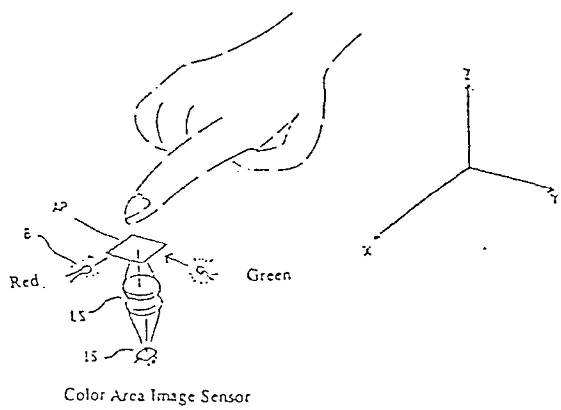

Figure 4. An improve method for fingerprint pattern scanning by using color area image sensor and LED's of different primary color

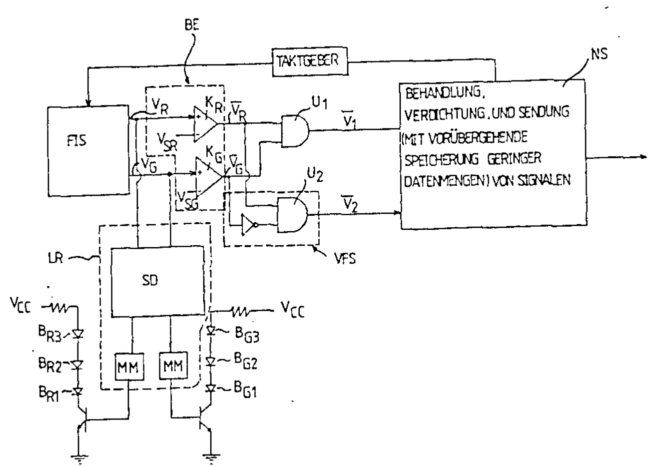

Figure 5. Hardware structure of this improved 3D optical sensing method, where RED and GREEN LED's are lighted by monostable multivibrators

4. 3D ANALOG SIGNALS PROCESSING

The output signals from R/G/B output ports of the color area image sensor are further processed to obtain those valuable information we want. Since the output signals are stored in the form of analog signal in the color area image sensor, much flexibility will be attained in the subsequent data processing.

For the simplicity in explanation, if only two kinds of LED's are used namely RED and GREEN are used, the same assumption as described in Sec.3, then we will find the R and G output will show s steep slope just corresponding to the both sides of ridges of the surface of finger, respectively. When these signals are converted into digital waveforms Vrd and Vgd by voltage compartors, respectively, it is found that the actual locations of both sides of ridges are not sensitive to the change of reference voltage used with voltage comparator. This unique feature will be further explained below. This can be seen in Fig. 6.

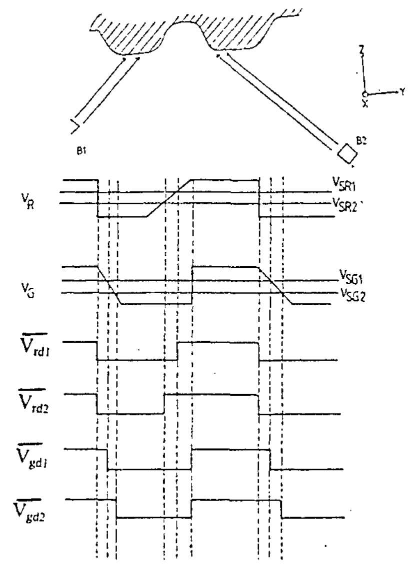

Figure 6. R and G output signals are converted into digital waveforms V_{rd1} and V_{gd1}, V_{rd2} and V_{gd2} means the waveform by using different reference voltage for compartor

4.1 Binary-like fingerprint pattern

The digital waveforms Vrd and Vgd related to R and G output signals can be used together with simple digital logic circuitry to obtain a signal binary-like fingerprint pattern as shown in Fig. 7. The locations in the change of digital signal waveforms Vrd and Vgd corresponds exactly to the both sides of the border of fingerprint. Moreover, these two locations are not sensitive to the changes of the reference voltage used in the voltage comparator as explained previously.

Since the reference voltage used to convert analog output signal of area image sensor may be influenced by many factors such as changes in environmental conditions, tolerance in assembly procedure and etc., therefore we have found that the signal binary-like fingerprint scanning techniques.

4.2 Prevention of counterfeiting

In case of a copied fingerprint pattern is used to replace the real finger for fingerprint optical scanning, then the R and G output will be the same owing the fact that is the image of a planar pattern and not the image of a surface with ridges and valleys. Consequently, the digital waveforms Vrd and Vgd can be used together with simple digital circuitry such as XOR gate to obtain a digital waveform Vcd which directly indicates whether the signals Vrd and Vgd are the same.

In this manner, the detection of counterfeiting is very easily to be achieved. Moreover, the counterfeiting by using a

chemical etched processed fingerprint pattern will also be detected owing to the fact that the etched pattern will be with a nearly vertical edge shape, and the borders of this kind of edge are clearly defined and digital signals Vrd and Vgd will be in a similar wave shape. As depicted in Fig. 8.

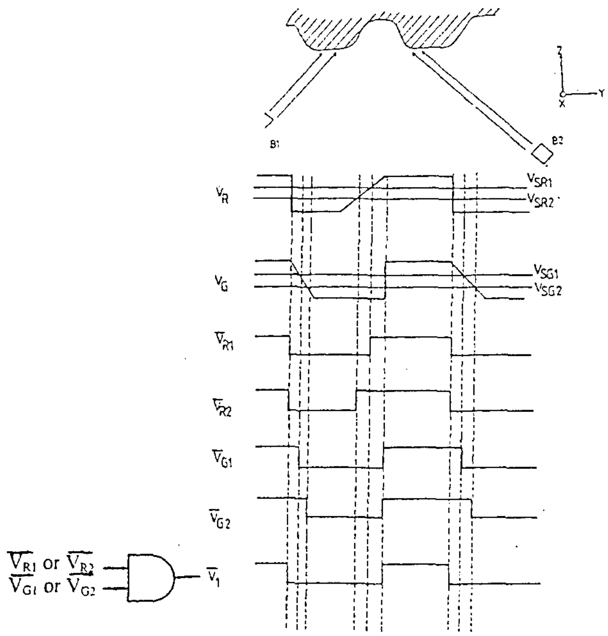

Figure 7. A binary-like fingerprint pattern can be obtained by AND of V_{rd} and V_{gd}

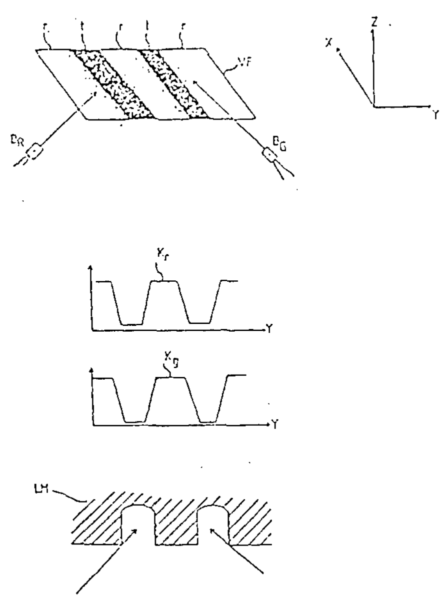

Figure 8. Prevention of counterfeiting for this improve method

5. TOTAL TIME FOR IDENTIFICATION PROCESS

The evaluation standard for fingerprint verifying techniques are FAR (False Accept Rate) and FRR (False Reject Rate). For the optimum expectation, the value of FAR and FRR should be low. Besides, for efficiently consideration, the time needed for authentication should be kept as low as possible. Total is the time needed for a complete cycle of authentication process, it consists of all the following time factors:

T1: time needed for picture imaging
T2: time needed for counterfeiting prevention
T3: time needed for data compression
T4: time needed for data encryption and transmission
T5: time needed for data decompression
T6: time needed for fingerprint verification

In our improved optical scanning method, those time factors T1, T2, T3, and T4 will be reduced.

Regarding the time factor T6, because a binary-like image pattern can be obtained by using the above mentioned improved optical scanning method, thus the time T6 needed for fingerprint verification may be reduced to a great extend owing to high quality fingerprint pattern if identified by a host computer in remote location.

6. DATA COMPRESSION AND TRANSMISSION OF FINGERPRINT PATTERN

The fingerprint pattern as obtained by using the above mentioned improved 3D optical scanning method will be much like a binary image pattern, this kind of image pattern is more suitable to the data compression than those image pattern as obtained by using other sensing method. Because a binary-like image pattern will have higher percentage of redundancies in its image pattern, and the aim of data compression is to reduce the number of bits required to represent the image pattern by removing these redundancies, thus a large portion of redundancies can be removed. In this manner, it is possible to develop a more efficient data compression scheme by using information theory concepts to process this binary-like image pattern.

Moreover, although the data compression can be categorized into two fundamental groups as lossless and lossy[5], where lossy compression scheme is more efficient for data transmission. Because the major purpose of the decompressed data of the above mentioned compressed data is for the characteristic extraction of minutia of the fingerprint to be used for identification in the remote host computer, in this case, a complete data recovery is not absolutely necessary. Besides, considering the total time required for identification is important in INTERNE environment, therefore the more efficient lossy compression scheme is more suitable to be used in this application. The general framework for a lossy compression scheme is shown in Fig.9.

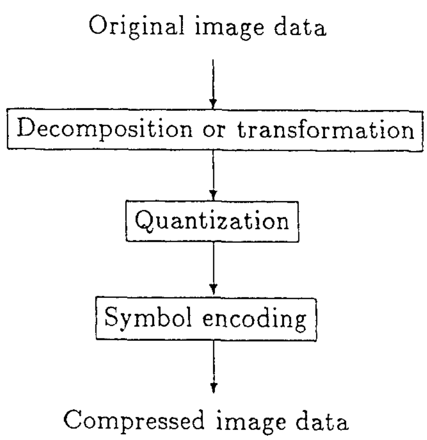

Figure 9. Lossy compression framework

7. CONCLUSIONS

The fingerprint optical scanning method as designed to take the full benefit of the recently developed E/O components, and characterized by using a plurality of high illuminance LED's with different wavelengths corresponding to the peak sensing wavelengths of the R/G/B output of the color CCD/CMOS area image sensor, a 3D-like image pattern can be easily obtained within a single exposure time period.

Moreover, by simple signal processing of those R/G/B outputs together, a binary-like fingerprint pattern can be obtained, this binary-like pattern is not sensitive to environmental conditions changes, this means the reliability of this fingerprint optical scanning method is greatly improved. Moreover, by another simple processing of R/G/B outputs together, the prevention of counterfeiting can be achieved to a greater extent.

Finally due to the high quality of the binary-like fingerprint pattern as mentioned above, the total time needed for authentication will be greatly reduced under the condition that the identification of fingerprint be processed by a host computer through communication links in remote location.

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